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A Report on the Investigation of the Corrosion At Preston School of Industry

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7. AUTHOR(S)

Stratfull, R.F.; Maxwell, W.S.; and G.R. Steffens

8. PERFORMING ORGANIZATION REPORT No.

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Department of Public Works
Division of Highways

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16. ABSTRACT

On May 19, 1960, Mr. Aldo Crestetto, Civil Engineering Supervisor, Division of Architecture, requested by letter that the Materials and Research Department perform a corrosion survey at the Preston School of Industry in Ione, California, under Inter-Agency Agreement S.A. 2235 and Work Order No. 4528-GC. It was requested that a corrosion survey be made to determine the extent of the corrosion problem as well as recommendations for the purpose of minimizing the corrosion problem as well as recommendations for the purpose of minimizing the corrosion of the underground pipe installations. A survey of the electrical and telephone lines was also made to determine their influence on the corrosion of the underground pipe.

Historically, the Preston School of Industry has been in the same location for approximately 67 years. In that time, underground piping has been installed and abandoned during various periods of construction. As a result, the ages and locations of many existing and abandoned facilities are not definitely known. Since no leak record has been kept at the school, a leak frequency curve could not be made. What is most important is that the number of leaks is increasing and has created a definite maintenance problem.

A corrosion study was made by representatives of the Materials and Research Department during the months of September and October 1960 at the Preston School of Industry. The results of this corrosion survey are included in this report.

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STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

A REPORT ON THE INVESTIGATION OF THE CORROSION AT PRESTON SCHOOL OF INDUSTRY

61-07

JANUARY 1961

State of California
Department of Public Works
Division of Highways
Materials and Research Department

January 1961

Lab. Project Auth. 72-S-6219

Mr. Anson Boyd
State Architect
Division of Architecture
1120 N Street
Sacramento, California

Attention: Mr. Aldo Crestetto, Civil Engineering Supervisor

Dear Sir:

Submitted for your consideration is:

A REPORT ON
THE INVESTIGATION OF THE CORROSION AT
PRESTON SCHOOL OF INDUSTRY

Study made by . . . . Structural Materials Section
Under general direction of . . . . J. L. Beaton
Work supervised by . . . . R. F. Stratfull
Report prepared by . . . . . . R. F. Stratfull, W. S. Maxwell, and G. R. Steffens

Very truly yours,

F. N. Hveem
Materials and Research Engineer

By
J. L. Beaton
Supervising Highway Engineer

RFS/WSM/GRS:mw
cc: N. Carter, CYA (5)

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I. INTRODUCTION AND HISTORY

On May 19, 1960, Mr. Aldo Crestetto, Civil Engineering Supervisor, Division of Architecture, requested by letter that the Materials and Research Department perform a corrosion survey at the Preston School of Industry in Ione, California, under Inter-Agency Agreement S. A. 2235 and Work Order No. 4528-GC. It was requested that a corrosion survey be made to determine the extent of the corrosion problem as well as recommendations for the purpose of minimizing the corrosion of the underground pipe installations. A survey of the electrical and telephone lines was also made to determine their influence on the corrosion of the underground pipe.

Historically, the Preston School of Industry has been in the same location for approximately 67 years. In that time, underground piping has been installed and abandoned during various periods of construction. As a result, the ages and locations of many existing and abandoned facilities are not definitely known. Since no leak record has been kept at the school, a leak frequency curve could not be made. What is most important is that the number of leaks is increasing and has created a definite maintenance problem.

A corrosion study was made by representatives of the Materials and Research Department during the months of September and October 1960 at the Preston School of Industry. The results of this corrosion survey are included in this report.

II. SUMMARY AND CONCLUSIONS

The corrosion of the water lines is the result of the creation of galvanic corrosion cells and long line currents. Galvanic corrosion is induced by soil conditions and dissimilar metallic piping. Long line currents are stray D. C. currents which are induced onto the surface of a pipe from an outside source. In this case, the outside source appears to be current leakage from A. C. transformers. The stray currents will eventually cause a corrosion leak at points where it discharges into the ground.

The leaks in the water system will continue at an ever-increasing rate if cathodic protection is not applied; therefore, for corrosion control, it is recommended that cathodic protection be applied to the piping system. A total of six small anode beds and rectifiers are recommended to be installed and their locations are shown on Exhibit II.

The soil in certain areas of the institution, where the corrosion problem is acute, is corrosive to metal pipe. In addition, stray electrical currents are emanating from the power house, transformers, and other sources. The concrete embedded steel and radiant heating in the dormitories are also causing corrosion of the underground pipe. These factors plus the corrosive soil are the cause of the corrosion problem.

The investigation of the electrical and telephone lines showed evidence of long line currents on the sheaths of these cables. In some locations it appears that these long line currents are causing corrosion of the sheath. This investigation did not delve into all of the causes of sheath corrosion as it was not considered to be economically feasible. From tests performed and after observing field conditions, sheath corrosion on the electric and telephone cables could be greatly reduced by eliminating the areas of standing water in the telephone and electrical cable conduit. Also, if the lead telephone sheath were coated with an inert substance, such as a reinforced neoprene jacket, it would be of benefit in combating corrosion.

After the installation of a cathodic protection system, periodic operational checks should be made by trained personnel. These personnel can be trained by the Materials and Research Department. It cannot be emphasized too greatly that a cathodic protection system of this nature should be periodically checked. The reasons are (1) that it will not control the corrosion of the pipe if not properly adjusted, and (2) there is a possibility that the electrical cathodic protection could corrode underground pipe both on and beyond the limits of the school. This could occur because of an electrical discontinuity in the existing pipe or by the installation of new pipe not electrically bonded to the cathodic protection system.

Written instructions for measuring the pipe to soil potential are included in the Appendix of this report. These pipe to soil potentials are to be used for checking the effectiveness of the cathodic protection units.

A section of the old 18" penstock line was removed, and its condition was observed. Upon inspection of the inside of the removed section of the penstock, internal corrosion of the pipe was noted. Holes up to 1/8" in diameter had perforated the pipe from the inside. These perforations were due to the water being corrosive. It is recommended that the penstock water be chemically analyzed. Thereafter, an analysis be made to determine the feasibility of chemically treating the penstock water to render it non-corrosive. The cathodic protection units will not prevent the internal corrosion of pipe.

III. RECOMMENDATIONS

1. Six (6) impressed current cathodic protection stations be installed as soon as possible.

2. The mechanical installation of the cathodic protection facilities be accomplished by contract.

3. The Division of Architecture prepare the final plans, specifications, and field inspection of the cathodic protection system.

4. The cathodic protection beds be installed at the locations indicated on Exhibit II, Equi-Resistivity Contour Map.

5. If the cathodic system is not to be checked periodically, that the corrosion control measures be abandoned.

6. When new metallic pipe is to be installed, the influence of this pipe on the cathodic protection system be determined, and, if necessary, the rectifier output be adjusted.

7. All underground pipe made electrically continuous. Most discontinuities on the main lines are shown on Exhibit III.

8. Where necessary, electrically isolate buildings with radiant heating systems.

9. Take monthly pipe to soil potentials at locations determined after initial installation of cathodic protection system.

10. A standard copper sulfate half-cell and a millivoltmeter be purchased by the school so that the maintenance personnel (who have been trained) may make the necessary monthly checks on the operation of the system.

11. That a complete pipe to soil potential survey be made between 30 days and six weeks after the installation of the new cathodic system and once a year thereafter.

12. All new metal pipe that is installed should be coated with an AWWA specification coal tar enamel or with a 10 mil thickness of polyethelyene or ployvinyl chloride tape coating.

13. That any new piping installed underground at this site be non-metallic where it is mechanically feasible.

14. Where new pipe is installed in expansive clay, the pipe be backfilled with a sand or non-expansive soil for a minimum distance of 3 inches all around.

15. When installing anode beds, avoid contact or crossing of electrical or telephone cables.

16. Installation of the cathodic protection system should be installed in two phases as follows:

Phase I

a. Electrically bond all utility lines in major leak areas as shown in Exhibit III.

b. Install anodes as noted in Exhibit II.

c. Perform field tests to determine size of rectifiers at the installed anode beds.

d. After installation of rectifiers, perform additional field tests in order to determine if any changes or additions are required in the original cathodic protection system.

e. In order to determine the influence of the radiant heating pipe and the concrete embedded steel on the cathodic protection system, Building Unit #4 should be electrically disconnected from the underground piping.

Phase II

a. If required, install additional anode beds in highly corrosive areas.

b. Perform field tests to determine size of rectifiers in new anode bed locations.

c. Perform additional field tests to determine if pipe in corrosive areas is adequately covered under cathodic protection.

d. If step "e" of Phase I proves feasible, then all buildings with radiant heating will be electrically disconnected from the underground pipe system on the soil side of the buildings by insulating couplings.

17. Determine the economical feasibility of chemically rendering the penstock water non-corrosive.

IV. TESTS

A. Pipe to Soil Measurements

Pipe to soil potentials were measured on all electrically continuous water and gas lines in the major leak areas. Exhibit III, Equi-Potential Contour Plan, shows that the majority of leaks that have occurred and will continue reoccurring are in the northern and eastern parts of the school.

B. Electrical Resistivity of the Soil

The electrical resistivity of the soil at the Preston School of Industry is shown on Exhibit II, Equi-Resistivity Contour Map. As indicated by the resistivity measurements, the soil varies from 230 ohm-cm to 25,000 ohm-cm. The resistivity of the soil in the area around the company buildings, where the greatest number of leaks has been experienced, is a corrosive soil which is approximately 1000 ohm-cm or less. The highly corrosive soil in this area will continue to cause corrosion of the piping.

C. Miscellaneous Tests

1. Electrical continuity tests were performed on portions of the underground pipe, and points of electrical discontinuity are noted on Exhibit III. These tests were not performed on all of the sprinklers or other small dimensioned distribution piping.

2. A preliminary field test was performed to determine the necessary current needed to obtain cathodic protection for all corrosive areas, and it was determined that partial cathodic protection located in the corrosive areas would be the most feasible and economical means of protection.

V. DISCUSSION

A. Electrical Interconnection of Underground Structures

In the company dormitories (Buildings E-K) field tests verified that the clean and dirty water lines are electrically connected to the concrete embedded steel and radiant heating in the buildings. A flow of current from the underground pipes through the soil to the buildings was detected by electrical measurements. As a result, the tests show that the radiant heating and concrete embedded steel in the buildings are cathodic to the underground pipe system and is one of the causes of the corrosion of the underground pipe.

When cathodic protection is applied, the radiant heating and concrete embedded steel in the buildings will absorb a large portion of the current needed to protect the underground pipe. This current loss to the buildings requires that additional current be supplied to protect the pipe. Therefore, the current required for corrosion control may be reduced by electrically insulating the buildings from the underground pipe. Additional reductions in the current requirements for corrosion control may be accomplished by electrically disconnecting the abandoned pipe from the pipe now in use. If further tests indicate that the abandoned pipe may be economically "cut loose" from the existing pipe, then it should be accomplished.

B. Soil Corrosivity

Field tests show that the average resistivity of the soil in the institution is about 2200 ohm-cm and the pH or hydrogen-ion concentration is 7.0, which indicates that the probable life of a standard 3/4" pipe is around 35 or more years. The probable life of 3/4" pipe in the corrosive areas is estimated at 25 years.

C. Cathodic Protection

The use of cathodic protection for protecting underground metals is a common engineering practice. Such a method is quite practical, but cathodic protection requires that close attention be directed to the possibility of corroding adjacent piping systems that are not included in the piping network under consideration. Therefore, it is necessary that all underground metallic structures at the institution be electrically interconnected.

It is probable that a few leaks will appear in the piping soon after the application of cathodic protection. The reason for the occurrence of "new" leaks is that the pipe may be so corroded that the corrosion products are acting as a temporary "plug". When cathodic protection currents are applied, hydrogen gas will be evolved on the surface of the pipe. This gas will originate between the metal surface and the rust, and the rust will be mechanically loosened due to the formation of the gas. If the rust is acting as a "plug", the loosening of this rust plug will result in a leak in the pipe. Also, movements of the soil resulting from variations in moisture content can loosen the "plug", and the resultant leak will be noticed.

If a leak is found in the piping system near a pipe joint, or other pipe, it is good field practice to electrically bond the pipe sections together as a standard repair procedure. Also, at the conclusion of the installation of the anodes and before the application of cathodic protection, the piping system should be again checked for electrical continuity.

The public utility companies which have service lines in the adjacent area should be notified in writing of the State's intentions so that cooperative tests can be performed to determine if this cathodic protection system would adversely affect their underground lines.

Six separate cathodic protection systems should be installed at the Preston School of Industry in the corrosive areas. The preliminary cathodic protection tests indicated that approximately 1600 amperes of current would be required to control the corrosion of all of the piping. This amount of current for cathodic protection is not economically feasible. Therefore, it is warranted only to protect the pipe in corrosive areas. This will greatly reduce operating and installation costs over that which would be required for complete corrosion control. The proposed anode bed locations are shown in Exhibit II.

D. Influence of Stray D.C. Currents on Underground Pipe Installations

Stray current corrosion occurs on buried or submerged metallic structures. It differs from all other forms of corrosion in that the current which causes the corrosion has a source external to the affected structure. Leaks will occur where the current leaves the pipe. Wherever current collects on a pipe, that section will be protected from corrosion.

The D. C. generator, located in the power house, has previously been used to supply electrical power to the entire institution. Only in the past four or five years has it been used on a stand-by basis for emergency power. Field tests show that stray D. C. electrical currents are induced onto the underground pipe when the D. C. generator is in operation.

It can be assumed that when the D. C. generator was constantly supplying power to the institution that it caused some sections of pipe to corrode and protected other sections. That this has occurred was found to be a fact when the alternating current was turned off and the direct current emergency power was turned on. A current flow was recorded on the penstock line that was caused by the flow of D. C. from the emergency generator. This current flow occurred after the A. C. power was off and the emergency D. C. current was supplying power to the institution. The current flow in the penstock line increased the corrosion rate of the underground pipe. A flow of current that resulted from the use of the emergency D. C. generator was found on other piping.

E. Survey of Electrical and Telephone Lines

A survey of the electrical and telephone lines was conducted to determine their influence on the corrosion rate of the underground pipe. Determination of current was obtained by means of voltage measurements on the lead shield of the telephone lines and the copper sheath of the high voltage electrical cables. The actual current flow is calculated and reported in Exhibit IV of this report.

These cables are electrically connected to the underground pipe through ground wires and concrete embedded steel in the buildings. In such a situation the pipes could cause corrosion of the telephone and electrical lines by inducing a D. C. current from some outside source and conversely the telephone and electrical lines could cause corrosion of the underground pipe by the same method.

Corrosion on a pipe or on electrical and telephone cable occurs where the current leaves the pipe or cable. It will most likely occur in an area where the cables are in standing water. Since a flow of direct current was measured on the cables, then this current flow is a contributing factor in the corrosion of the sheath of these cables. The points of current discharge on the cables are not accurately located, but occur where there is a current drop between two sets of manholes. This current drop and probable areas of corrosion are shown in Exhibit IV.

VI. APPENDIX

A. Method for Measuring Pipe to Soil Potentials

Monthly cathodic protection potential readings must be obtained and recorded so that any erratic changes noted in the system can be investigated and, if necessary, corrected.

Readings are obtained by conducting a pipe to soil potential survey using a high resistance voltmeter and a standard copper sulfate half-cell.

All pipe under a cathodic protection system has a certain electrical charge. The pipe to soil potential survey measures the amount or quantity of the electrical charge.

A high resistance voltmeter is used to obtain adequate sensitivity. The copper sulfate half-cell is used as a stable reference point as it has a constant unchanging electrical charge. The voltmeter measures the difference between the electrical charge on the pipe and the copper sulfate half-cell.

Use the following procedure for conducting a pipe to soil survey:

1. Attach positive (+) lead from voltmeter to copper sulfate half-cell.
2. Attach negative (-) lead from voltmeter to pipe being checked.
3. Wet ground at check point.
4. Place copper sulfate half-cell on wet ground at check point.
5. Read and record voltage.

A record of all readings should be kept and any discrepancies in the system be brought to the attention of the corrosion engineer. Readings can be recorded as shown on Exhibit I.

B. Equipment for Pipe to Soil Potential Survey

Simpson Model 269 AC-DC Volt-Ohm-Microammeter 100,000 ohms/volt DC, 5,000 ohms/volt AC, w/carrying case	$ 99.50
8" Copper Sulfate Electrode (J. L. Collins Co., Angleton, Texas)	11.00

Cupric Sulfate-Fine Crystal Reagent (1 pound)	$ 1.25
Total Cost Estimate	$ 111.75

C. Copper-Sulfate Half-Cell

1. Preparation of Solution:

The copper sulfate half-cell contains a solution that is made from crystals of cupric sulfate and water. The amount of each used to charge the half-cell is as follows:

a. Pour enough cupric sulfate crystals into the half-cell to fill the cell to a height of 1 inch or more above the bottom of the cell.

b. Add enough distilled water to fill the cell to within ½ inch of being full.

c. Screw the cleaned copper electrode into the cell and allow to stand overnight before using.

2. Maintenance of Half-Cell

When the half-cell is not in use, the wooden tip should be kept clean and covered with the rubber cap to maintain long life.

At the time of each monthly measurement, the half-cell should be emptied and then refilled with a new solution. The copper rod should be cleaned to a bright appearance with sandpaper to remove the copper oxide coating on the copper rod. Before inserting the copper electrode into the cell, wash the rod with distilled water to remove any dirt, etc.

CAUTION: The cupric sulfate crystals are poisonous. Wash hands after using the half-cell and the cupric sulfate crystals.

D. Tentative Specifications

Rectifier:

Good-All "Add-A-Stack" Model Y36-24 selenium rectifiers or equal. The output shall be variable from 0 to the maximum voltage in a minimum of 10 equal steps.

The rectifier shall perform satisfactorily at maximum output at an ambient temperature of 130° F. The unit shall have built-in thermal and input and output overload protection.

A D.C. ammeter with suitable range switching shall be installed. The scale ranges of such an ammeter will not exceed 140% of the rated output reading of each selenium stack.

The entire installation shall be mounted in a vandal-proof enameled steel box of code gauge thickness. The box shall have a locking cover and padlock, and it shall be suitable for wall or bench mounting.

Anodes:

The impressed current anode shall be "Durion" 2" x 60" Type D-LO high silicon cast iron anodes, or equal high silicon cast iron anodes with five feet of A.W.G. #8 oil resistant waterproof cable or equal.

Anode Backfill Materials:

The anode backfill material shall be "National" BF-3 backfill, a prepared mixture made of graphite particles and an alkalizer or equal.

Installation of Anodes:

Impressed current anodes shall be placed at the designated locations in the following manner:

1. Auger or otherwise construct an anode hole of 10" in diameter 10' below grade.

2. Fill bottom of hole with special backfill material to a compacted depth of 1', which is 9' below grade.

3. Center anode carefully in hole and add backfill material in one foot compacted layers until the backfill is approximately one foot above anode.

4. After making electrical connections, backfill the remainder of the hole with sand. Top soil may be used in the top six inches.

Wiring:

Standard copper anode lead wire shall be C.P.S. OR-1 600 volt A.W.G. #2/0 or Anaconda type CP cathodic protection cable or equal.

All "in line" splices and all splices of the anode lead wires to the feeder lines shall be made with the Cadweld process or equal.

All underground wire splices shall be adequately protected from current leakage through the soil by using a Scotch-Cast Splicing Kit containing No. 4 resin or equal.

The main feeder wire from the rectifier to the anode beds and pipe shall be buried at least two and a half feet below the original ground or at a depth which will insure protection of the wire from accidental severance by cultivation or excavation.

The main feeder wire from the rectifier to the anode beds and pipe shall be encased in conduit to the depth of burial of the wire. The length of conduit shall be sufficient to protect the feeder wire from tampering or accidental severance and will traverse the distance between the rectifier and that point where the wire is buried at specification depth. Suggested Cathodic Protection Material Suppliers:

Harco Corporation
P. O. Box 7026
16901 Broadway Avenue
Cleveland 28, Ohio

Electrical Facilities, Inc.
1307 66th Street
Emeryville, California

Frost Engineers Service Co.
P. O. Box 767
Huntington Park, California

The Pipeline Protection Co.
420 Market Street
San Francisco 11, Calif.

Brance Kracky Co.
4411 Navigation Blvd.
Houston, Texas

Pipe Line Anode Corp.
Box 996
Tulsa, Oklahoma

Pipeline Coating & Eng. Co.
5501 South Santa Fe
Vernon, California

Vanode Corporation
880 East Colorado St.
Pasadena 1, California

E. Cathodic Protection Cost Estimate

Phase I

Description	Quantity	Unit Cost	Material Cost	Labor Cost Hours
Anodes - Durion 2"x60"	57 each	$18.00	$1026.00	114
Coke Breez - 57 holes	15000#	5.25 cwt	787.50	171
Rectifiers - One Stack Y-28-44	2 each	775.00	1550.00	8
Rectifiers - Two Stack Y-28-44	3 each	900.00	2700.00	18
Rectifiers - Four Stack Y 28-44	1 each	1050.00	1050.00	8
3/4" Conduit (wrap 200')	300 ft.		95.00	18
#2/0 wire 600 volt AWG	900 ft.	305.00/M	274.50	29
#10 TW	700 ft.	19.00/M	13.30	7
#2	600 ft.	200.00/M	120.00	12
#4/0	1000 ft.		670.00	40
Misc. Elec. Parts	L.S.		130.00	6
Trench	2400 ft.	20¢/ft.		96
10" holes (excavation)	57 each			171
Jumper w/Scotch Wrap & weld	15 each	$5.00 ea.	75.00	22
Excavate for Jumpers	15 each			30
Misc. Excavation & Jumpers	L.S.		40.00	16
Insulated Coupling Installed	3 ea.			70
Materials Total			8531.30	836

Total Materials Cost	$ 8531.30	
Sales Tax @ 4%	341.25	
Labor @ $5.00/hr.	4180.00	
Insurance	400.00	
Engineering	1500.00	
Sub-Total	14952.55	
20% Profit and Overhead	2990.51	
Total Cost	$ 17943.06	Say $18,000.00

E. Cathodic Protection Cost Estimate

Phase II

Description	Quantity	Unit Cost	Material Cost	Labor Cost Hours
Jumpers w/Scotch Wrap & Weld	8 each	$ 5.00ea.	$ 40.00	12
Excavation for Jumpers	8 each			16
Anodes	10 each	18.00ea.	180.00	20
#2 Wire	300 ft.	200.00/M	60.00	6
Misc. Elec. Parts			60.00	3
Rectifier - One Stack Y 28-44	2 each	775.00ea.	1550.00	8
3/4" Conduit	100 ft.	25.00/C	25.00	6
Misc. Wire	200 ft.	19.00/M	4.00	2
Coke Breez--250#/hole	2500 lb.	5.25/CWT	131.00	30
Anode Holes	10 each			30
Trench	300 ft.			12
Insulated Coupling Installed	24 each			500
Total Materials Cost			$ 2050.00	645

Total Materials Cost	$ 2050.00
Sales Tax @ 4%	820.00
Labor @ $5.00/hr.	3225.00
Insurance	85.00
Engineering	2500.00
Sub-Total	$ 8680.00
20% Profit and Overhead	1736.00
Phase II Total Cost	$ 10416.00 Say $10,500.00

(Final Cost)

Phase I	$ 18,000.00
Phase II	10,500.00
Total	$ 28,500.00

F. Cathodic Protection Record For ____________________ 19___.

I. (a) Rectifier No.

Rectifier No.	Volts	Amps
______	______	______
______	______	______
______	______	______
______	______	______
______	______	______
______	______	______
______	______	______

Check Point No.	*P/S at Present Rectifier Setting	*P/S After Rectifier Setting
______	______	______
______	______	______
______	______	______
______	______	______
______	______	______
______	______	______
______	______	______

Rectifier No.		Volts	Amps.
______	Readjusted to	______	______
______		______	______
______		______	______
______		______	______
______		______	______
______		______	______
______		______	______

NOTE:

Settings to be changed only if a particular check point shows that the pipe in that area is less than 0.85 volts.

* P/S Pipe to Soil Potentials

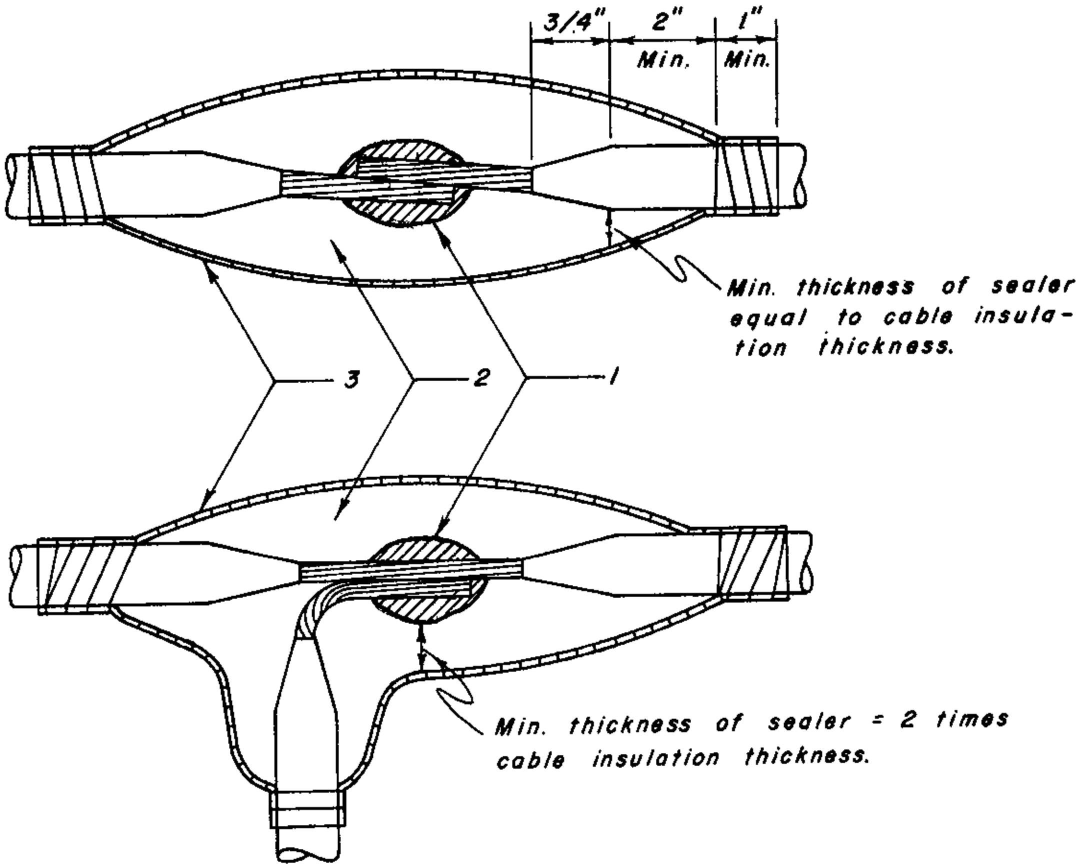
F. I. (b) Leak Record

	Date Leak Detected	Location and Remarks
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		

NOTE: Forward monthly copy to Corrosion Engineer, Materials and Research Department, Sacramento, California.

EXHIBIT V

CATHODIC PROTECTION
CABLE SPLICING DETAIL



1. Welded connection by the "Cadweld Process."

2. & 3. Scotchcast Splicing Kit utilizing an epoxy type resin or equal.

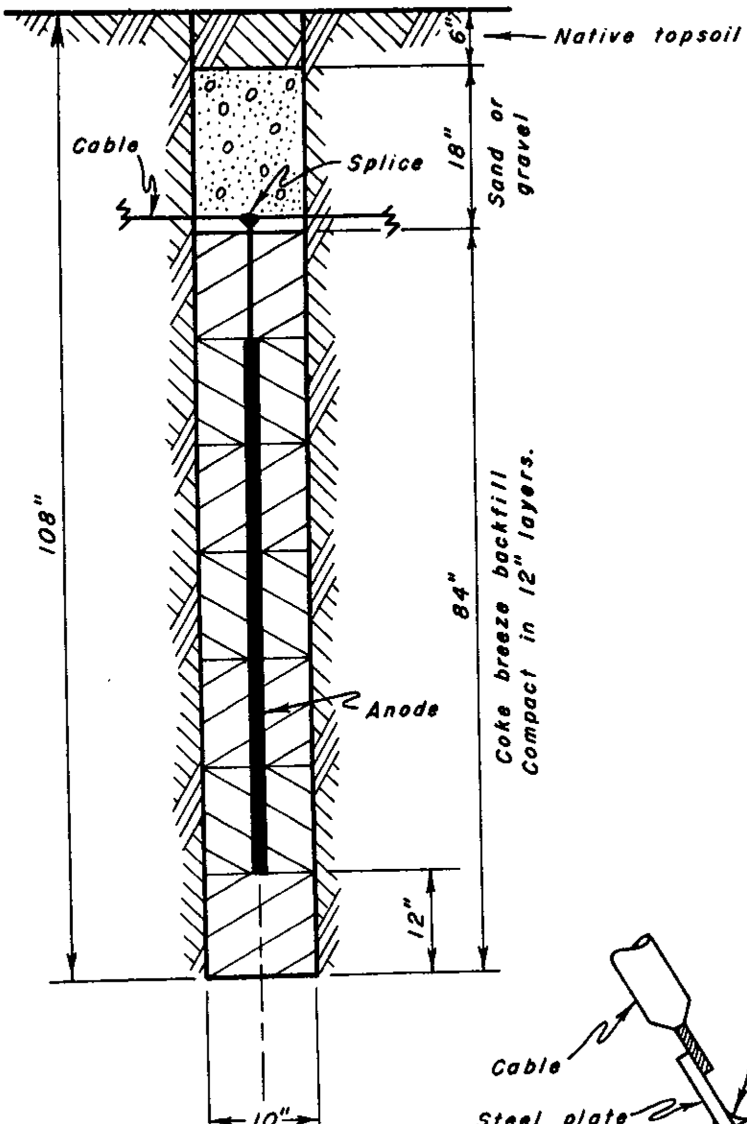
Note:

Cable at the splice shall be free of dirt, grease, or other foreign matter prior to the application of sealing materials.

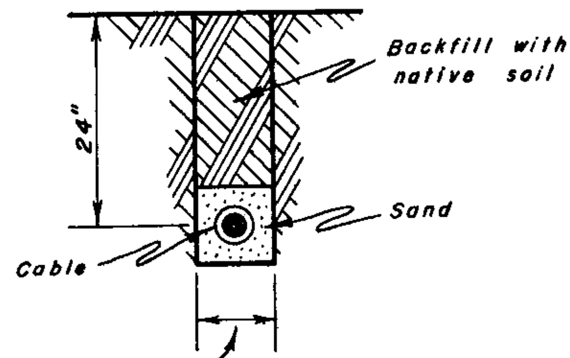
EXHIBIT VI

CATHODIC PROTECTION DETAILS

ANODE DETAIL

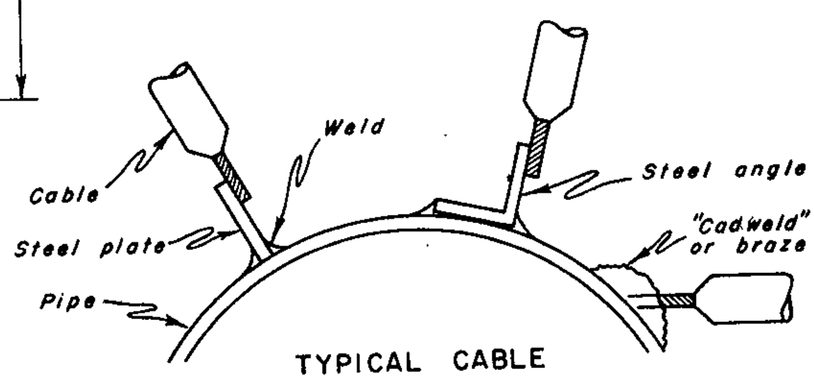


CABLE DETAIL



Cable trench width equals 3" plus O.D. of cable.

Cable shall have a min. of 1 1/2" sand blanket all around in expansive clay soils. In sandy soils, omit sand blanket and trench width to be minimum of 1" plus O.D. of cable.

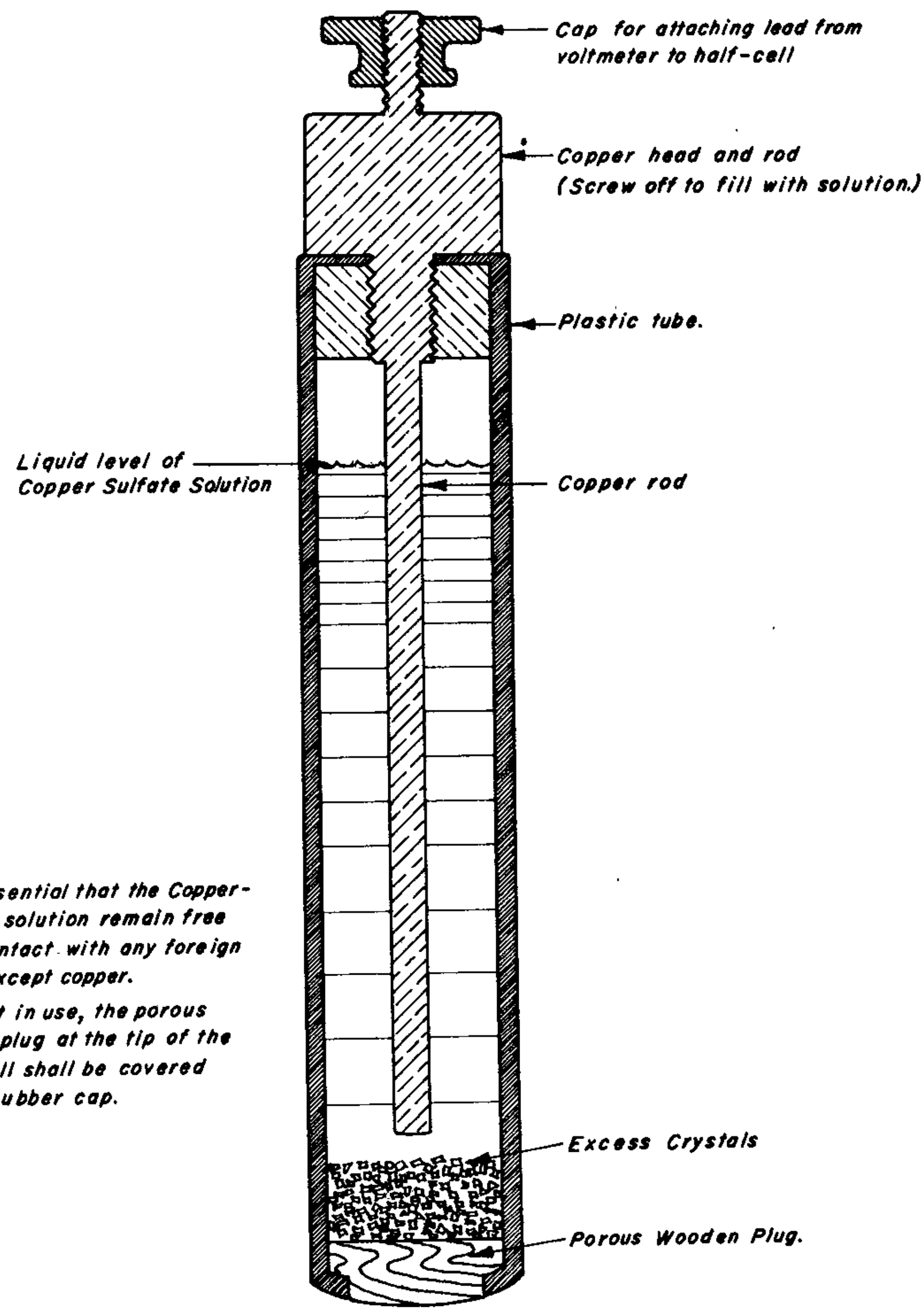


TYPICAL CABLE CONNECTIONS TO PIPE

Minimum dimensions of steel connector to be 3/8" thick and 2" in other directions. Cable to have a min. of 1" length brazed or otherwise connected to steel connector or pipe. The steel connector is to be welded all around. Pro-Seal EP-711, or equal, shall be spread a min. of 1/2" thick 3" beyond all exposed metals used for connecting the cable to the pipe. A sand blanket shall be placed 6" in all directions from the cable connection prior to backfilling with native soil.

EXHIBIT VII

SECTION VIEW OF COPPER SULFATE HALF-CELL



Note:

1. *It is essential that the Copper-Sulfate solution remain free from contact with any foreign metal except copper.*
2. *When not in use, the porous wooden plug at the tip of the half-cell shall be covered with a rubber cap.*